LONG DISTANCE TRANSPORT OF ILLINOIS RIVER DREDGED MATERIAL FOR BENEFICIAL USE IN CHICAGO

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ABSTRACT

Sedimentation severely impacts aquatic habitat along the Illinois River system in Illinois. The problem is especially severe in backwater lakes and the Peoria Lakes that are bisected by the navigation channel. The State of Illinois and the US Army Corps of Engineers, in cooperation with local governments and other organizations, are investigating methods of restoring the river's watershed. Key elements of the developing restoration plan include reducing future sedimentation and removing large quantities of sediment from the backwaters.

This paper reports on a pilot project for sediment removal and beneficial use. Sediment mechanically excavated from Lower Peoria Lake is being transported by barge 270 km (168 mi) for use as topsoil. It is being placed on fields at the old US Steel South Works mill bordering Lake Michigan. The site is currently covered with slag and has no topsoil. The area will become part of the Chicago Park District's lakefront park system.

Keywords: Brownfield, topsoil, ecosystem restoration, Peoria Lake, restoration

INTRODUCTION

The ecological restoration of the Illinois River, its backwaters and tributary watersheds is under investigation by the State of Illinois and US Army Corps of Engineers in cooperation with numerous local governments and other organizations (Bhowmik, *et.al.* 2000). Sediment deposition is a major problem. Backwater lakes (used here in reference to areas connected and unconnected to the main channel as well as lakes bisected by the river channel) in particular have severely degraded, with capacity loss exceeding 70% in a 1985 survey (Demissie *et.al.*1992). There are few sections along the river outside of the navigation channel and maintained marinas where water depth exceeds .61 m (2 feet). This greatly limits habitat for aquatic organisms, especially fish that need about 2 m (6 feet) for overwintering.

The removal of millions of cubic meters of sediment to restore depth to backwaters and side channels is an objective of the restoration effort. Beneficial use of sediment as landscaping soil on brownfields, strip mines, highway borders and other areas is a potential use for large quantities of this material (Marlin, 2002). Unlike much of the material in the navigation channel, which is sandy; sediment in the backwaters is generally fine grained. Weathered river sediment is similar in texture and productivity to native central Illinois topsoil and readily supports plant growth in greenhouse and field environments (Darmody *et.al.* 2002 and 2004). Studies of the sediment's physical and chemical properties are ongoing to help determine the effects of sediment removal and placement options on aquatic and terrestrial habitats (Machesky, et al, 2004 in press).

As with most bulk materials, the economic viability of sediment-derived topsoil will depend upon efficient handling and transport. This is particularly true where the dredging is performed in a setting at considerable distance from sites needing soil. Another important consideration is the location where soil is needed. Central Illinois is covered with some of the most fertile soil on earth, making it difficult to justify adding soil to most local farmland. Possible exceptions include several areas where sandy soils may benefit from conditioning with sediment that would improve several characteristics including water-holding capacity. Local urban needs are also limited due to relatively low population densities near most backwaters. As shown in Figure 1, the Illinois River connects central Illinois with Chicago and the Mississippi River near St. Louis, Mo. Barges from the restoration areas near Peoria can, therefore, reach the Chicago and St. Louis Metropolitan areas as well as some ports on Lake Michigan.

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The State and Corps of Engineers conducted small-scale handling and transport demonstrations with river sediment (Marlin 2003a, 2003b and 2003c). The sediment is readily excavated and has a consistency similar to that of toothpaste. It was handled without problems by concrete pumps, belt conveyors, a variety of dump trucks and barges. It can be placed on fields without needing an engineered containment to keep it from flowing off site, and does not easily erode.

THE PROJECT

Site Descriptions

The US Steel South Works Steel Mill (Figure 2) occupied 232 ha (573 acres) on Lake Michigan on Chicago's south side at the mouth of the Calumet River at river mile 333 (536 km upstream from the Mississippi River). The mill was established in 1880 and was closed in 1992. All structures except the ore walls have been removed and the site surface is largely slag with some concrete foundations and roads. There is no topsoil on the site. An environmental cleanup was completed in 1997 and the Illinois Environmental Protection Agency has determined that the site needs no further remediation. The Chicago Department of Planning and Development has plans for the area that include a mixture of public parks, residential, light industrial, commercial, and entertainment facilities. The City has constructed roads and other infrastructure at the site. US Steel is in the process of conveying 40.5 ha (100 acres) of lakefront property to the City. The Chicago Park District will integrate them into Chicago's renowned system of lake front parks (City of Chicago, 1999). The project will place about .91 m (3 ft) of sediment on a 6.9 ha (17-acre) parcel on the south side of the slip, with the remainder placed on northern parcels.

Lower Lake Peoria is a 1093 ha (2,500 acre) bottomland lake that is essentially a wide spot in the Illinois River. An alluvial fan separates it from Upper Peoria Lake that covers an additional 4816 ha (11,900 acres). The lakes average .76 m (2.5 ft) deep except for the navigation channel that flows through them at an average depth of 5.1 m (16.7 ft). Together the lakes are about 32.2 km (20 mi) long and have a primarily agricultural upstream drainage area of 3,565,119 ha (13,765 sq mi) and a local drainage area of 103,600 ha (400 sq. mi.) including ten local streams. In 1900 Lake Michigan water was diverted to the Illinois River converting some floodplain to water. In the 1930s locks and dams were constructed that further increased the water level to maintain a minimum navigation pool at elevation 134.1 meters MSL (440 ft). Between 1902 and 1904 the Corps of Engineers mapped the floodplain at .3 m (1 ft) contours. These maps make it possible to determine the depth of sediment accumulated during the past 100 years over much of the river's length (US Army Corps of Engineers, 2002).

Fon du Lac Park District's Spindler Marina is located at river mile 165.3 (266 km) on Lower Peoria Lake at East Peoria (Figure 3). The 823 m (2,700 ft) recreational boat channel connecting it to the navigation channel is subject to sedimentation and periodically requires maintenance dredging. This location was selected for collecting the sediment for movement to the South Works site because it had an existing dredging permit, and an ample supply of sediment that had previously been tested for chemical contaminants and agronomic characteristics. Sediment depth over the 1903 bottom ranges from 3.7 m (12 ft) near the navigation channel to less than 30 cm (1 ft) near the marina entrance. Water depth varied from 1.2 to .5 m (4 to 1.5 ft) over the same distance. The project calls for removing sediment from the channel until the combined sediment and water depth becomes too shallow for loading standard river barges.

After loading, individual barges are fleeted at Peoria prior to being added to 15 barge tows heading toward Chicago on the navigation channel. During the trip the tows pass through five locks and dams. They are fleeted again at Lockport, Illinois, into smaller tows to navigate the narrower channel through the metropolitan area. They are then taken to the slip at the north side of the project site for unloading.

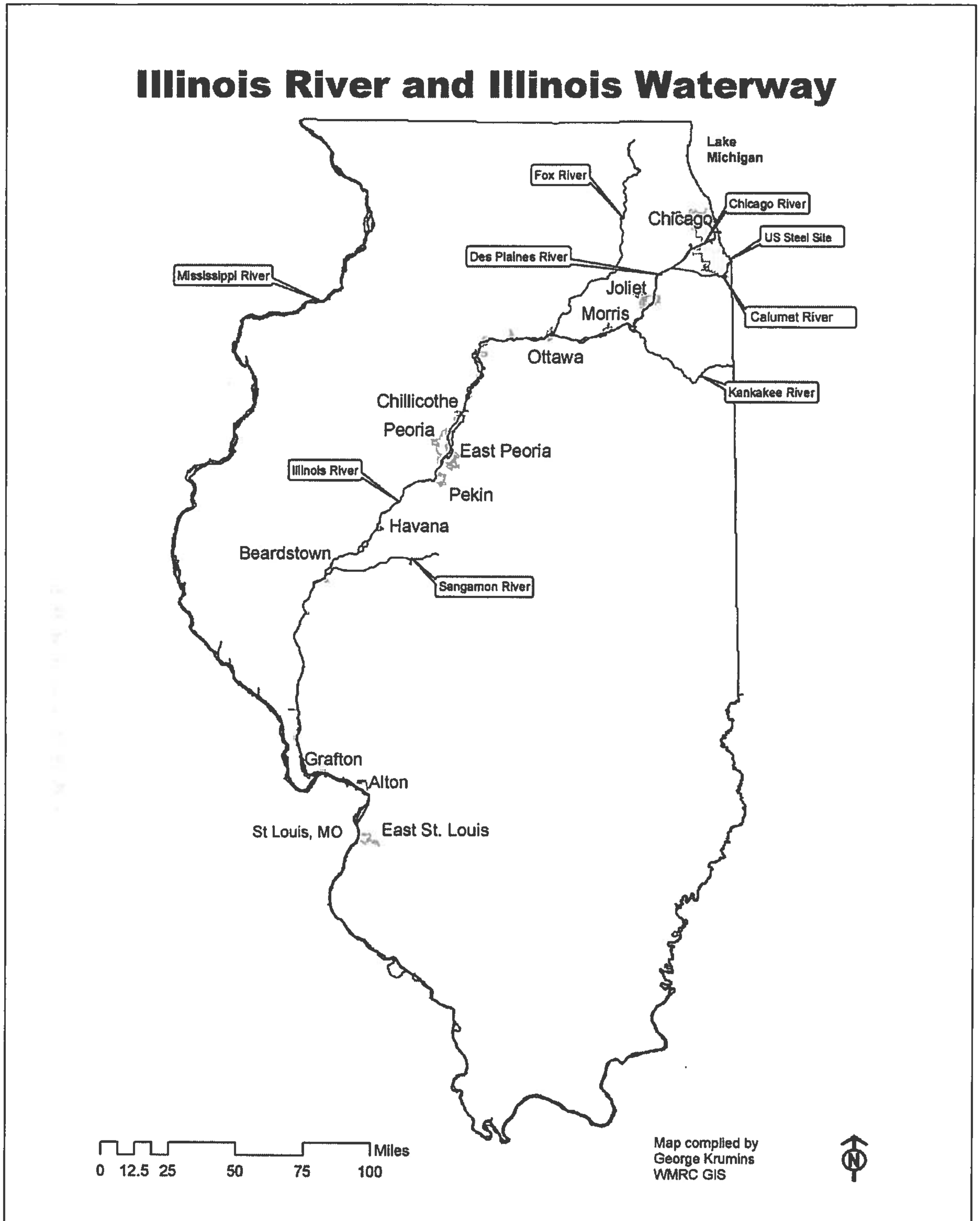

Figure 1. Sediment for the project was collected at East Peoria in shallow water near Illinois River mile 165 (265 km) along the Spindler Marina recreational boat channel. It was then taken by barge to the old US Steel South Works site in Chicago on Lake Michigan RM 333 (536 km). The final leg of the journey was on the Calumet River. The Illinois Waterway connects the Mississippi River near St. Louis, Mo. with Lake Michigan via the Illinois, Des Plaines, and Calumet Rivers.

Figure 2. The lakefront edge of the old US Steel South Works site is receiving reclaimed topsoil dredged from Lower Peoria Lake. Barges arrive via the Calumet River in the lower part of the photo and unload in the slip in the center of the site.

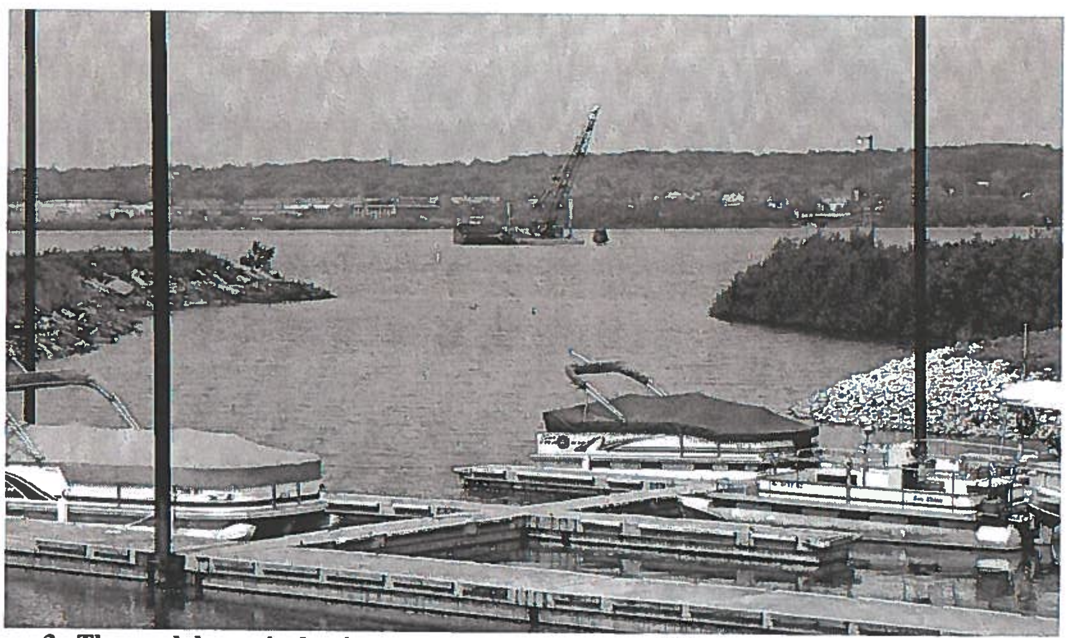

Figure 3. The work barge inches its way toward the Spindler Marina at East Peoria Illinois as it fills a hopper barge destined for Chicago, 270 km (168 mi) upriver. The Peoria Lakes are about 32 km (20 mi) long and about 1.6 km (1 mi) wide. Sedimentation has decreased their average depth to approximately .76 m (2.5 ft) during the past century.

Cooperating to Overcome Hurdles

Beneficial use of sediment as reclaimed topsoil is a goal of the Illinois River restoration effort. Demonstrating its feasibility on a large scale is necessary if private and governmental agencies are to have a basis for planning future projects, where the various beneficiaries might share costs. Finding a scenario that matched the various state, federal and local funding availability, as well as regulatory and procedural requirements proved difficult. Illinois Lt. Governor Pat Quinn, as chair of the Illinois River Coordinating Council, called a meeting of interested agencies in June of 2003 to discuss moving about 24 barges of sediment to the South Works site that fall. The lack of a Federal appropriation and local sponsorship requirements made it impossible to cost-share a project with the Corps of Engineers in that timeframe. It was decided to proceed with state and local resources if possible.

Over the next two months the existing Spindler Marina dredging permit was modified to enlarge the channel and move material to Chicago. Discussions with several agencies lead to a risk assessment of the sediment that concluded it was suitable for use on the site. The Chicago Department of Planning and Development had previously applied for a $5 million grant from the state for work at the site that had been approved, but not yet funded. The City decided to use $1.4 million of this to obtain and place 95,254 metric tons (105,000 tons) of wet sediment, if the funding materialized. Intergovernmental agreements were signed formalizing the roles of the Chicago Park District, City of Chicago, and Illinois Department of Natural Resources. Funding was approved in April 2004 and the project began.

Dredging

Dredging began on April 6 using a work barge with a Manitowoc 3900 crane and a Cable Arm high profile navigation bucket designed to remove soft sediment with minimal turbidity. The bucket weighed 3175 kg (7000 lb) and held 4.2 cu m (5.5 cy). Material was placed in standard uncovered hopper barges with a 1361 metric ton (1500 ton) capacity. It was soon apparent that the bucket was delivering too much free water into the barges. Holding the bucket above the water while it drained, produced a better product, but added significantly to the time needed to fill a barge. Observation indicated that the bucket was adequately penetrating the initial 1.8 m (6 ft) of sediment. However, in deeper sediment the bucket closed without fully filling, allowing water to enter. A conventional rehandling bucket was tried, but encountered similar problems.

A low profile, high-density Cable Arm bucket weighing 5897kg (13,000 lb) was brought in along with a Manitowok 4000. This 4.6 Cu m (6 cy) bucket readily penetrated the sediment and its screens rapidly drained water while holding in solids (Figure 4). This bucket produced very little free water when digging in soft sediment. With the heavier bucket it was possible to fill 1.5 to 2 barges per day. Delays were caused by mechanical breakdowns or weather conditions that made operations unsafe.

Sample cores were taken along the dredging path using a vibracore that penetrated the sediment to a depth of 3 m (10 ft). Subsamples were then taken of the recovered material and moisture content determined. The moisture content (dry weight basis) of the two cores in the area dredged as of the writing of this paper is presented in Table 1.

Table 1. Moisture content of vibracore sediment samples along dredging path (dry weight basis).

Core	Sample length	N subsamples	% Moisture	Range
136	2.38 m (7.8 ft)	10	88.4 %	72 – 101 %
137	2.65 m (8.7 ft)	11	92.6 %	88 – 101 %

Figure 4. Cable Arm bucket placing high solids sediment in a hopper barge on Lower Peoria Lake.

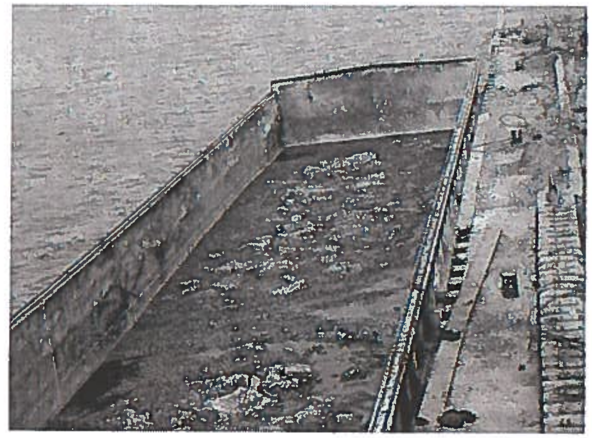

Figure 5. A crust has formed on higher sediment as rainwater fills low spots as barge awaits unloading in Chicago.

Unloading and Placement

The first barge was unloaded on April 13. The barges are unloaded from a slip adjacent to the South Works site with a Manitowoc 4100 and 7.6 cu m (10 cy) Hawco bucket. The operator partially fills the bucket to avoid spillage to Lake Michigan. Two bucket loads fill Volvo BMA 35 six wheeled mining trucks that carry sediment for placement on the field (Figures 5, 6 and 7). If any free water is present, it is pumped from the barges onto a slag site or the ore walls prior to unloading. The water is mostly from rainfall. A small endloader is placed in barges to assist in removing the last of the sediment.

Sediment samples were taken from individual truckloads soon after they were dumped. The samples were placed in plastic bags and taken to a laboratory for moisture content determination. A number of samples were taken from several barges. Sometimes a series of trucks loaded from a barge was sampled and another series was taken from the same barge at a later time. As shown in Table 2, there was considerable variability in the moisture content within barges and over time. However, Table 2 indicates that the dredging operation is becoming more adept at keeping free water out of the barges.

The sediment was cohesive and had a toothpaste-like consistency. It flowed from stationary trucks and formed piles .76 to .91 m (2.5 to 3 ft) high. Moving trucks spread material in thinner layers. A Caterpillar bulldozer spread the material 10 to 14 inches deep after it was dumped. The sediment was displaced by the tracks, leaving ruts that exposed the underlying slag (Figure 8). This left shallow windrows of material that were exposed to sun and wind on three surfaces. It began drying immediately and desiccation cracks appeared within two hours.

Table 2. Moisture content (dry weight basis) of sediment samples from individual truckloads from barges. Groups indicate where at least a half hour separated a series of samples from the same barge.

Date	Barge	N	Groups	% Moisture	Range
Apr 13	AT 503B	8	2	106 %	88 – 121 %
Apr 19	XL 259	4	1	104 %	100 – 109 %
April 22	XL 352	6	2	89 %	81 – 95 %
April 22	XR517B	3	1	100%	95 – 107 %
May 5	XL 163	2	1	81 %	80 – 82%
May 5	XL 501B	2	1	86	80 – 93%

After seven days, material placed on the first day was bulldozed into a long pile about four feet high. The dozer took the top 20 to 25 cm (8 to 10 in) of relatively dry material and left the soft, wet bottom layer. The clods in the pile varied from totally dry to moist and comfortably supported a person's weight after a day. The trucks then placed more wet sediment on the bulldozed area. This process continued with the piles growing to six feet high over the next two weeks. As space grew more limited on the initial site, material was bulldozed while wetter and piled deeper prior to moving the equipment to the northern fields. The contractor will place more material on the southern area after the sediment there has had time to dry and be pushed into piles (Figure 9).

Figure 6. Two bucket loads of sediment fill a mining truck.

Figure 7. Wet sediment pours onto a slag field destined to be a park.

Figure 8. A bulldozer spreads freshly poured sediment into a layer about a foot thick. The tracks expose the porous slag base and leave rows that hasten drying.

Figure 9. The Chicago Park District's chief landscape architect stands on a pile of reclaimed topsoil that was pushed up after drying on the slag field for 7 days. A second higher pile is drying in front of her while other material is lying on the field.

During the first five weeks of placing material the temperature ranged from –3 to 27 degrees C (27 to 80 degrees F) and it rained several times. A 5 cm (2-in) rain on a Friday left water standing in the tracks through the sediment on the field. By the following Monday the water had evaporated or soaked into the porous slag. Drying was enhanced by wind blowing off the lake. Annual rye grass seed sown by hand on a pile of wet sediment germinated after 10 days. The pushed up piles were hydro seeded with perennial rye grass. By May 17 some of the piled material was breaking up into small peds.

DISCUSSION AND CONCLUSIONS

The project is progressing largely as expected with 28 of an expected 69 barges unloaded. All of the sediment received in Chicago has been cohesive enough that it stays where placed despite variability in moisture content between barges and truckloads. The variability within barges is likely due to the fact that the sediment does not totally mix in the barges. Some buckets bring up large blocks of dense sediment that stay intact within the barge. Other loads contain sediment that sloughed off in the cut and mixed with water prior to being excavated. This was particularly true in the case of the initial barges loaded with the lighter clam shell buckets. Any given barge load contains cohesive blocks of sediment and material that is more fluid (see Fig. 4). Many of the barges arriving at the site contained mounds of crusted sediment. As a result, material placed in the trucks and on the field also varied in moisture content.

The unloading operation is efficient with two barges emptied per day. The mining trucks are well suited to moving the sediment and can drive through wet material without becoming mired. The unloading bucket seals tightly and very little material escapes the bucket. The sediment also stays in the trucks and does not drip through the tailgate. Mud on the haul road is almost exclusively from the tires.

The sediment dries well and is beginning to form soil structure similar to that observed in the demonstrations. The few foreign objects observed to date are mainly beer cans and small pieces of wood.

The project would benefit from ready access to more land. The parcels are separated and trucks are not allowed to transport material from the northern to the southern parcels. Thus the crane must be moved in order to switch parcels. Since the southern parcel needs a greater soil depth, more wet sediment is being placed there than can dry rapidly. The material will still form soil structure, but it will take longer than desired.

The backwater areas where barges can be loaded as in the current project are limited to some portions of the Peoria Lakes and a few other areas where the combined water and deposited sediment depth is sufficient to load standard barges. Therefore, it is important that planners of future projects determine whether the original bottom is suitable for use as reclaimed topsoil if barges are to be loaded with conventional cranes. A shallow water excavating system that can transport sediment to the navigation channel or shore would allow dredging in most backwaters.

Progress to date indicates that there are no technical difficulties with the handling of the sediment to prevent it from being transported and placed in large quantities at sites in need of topsoil. The type of vehicle used to transport the material from barges to a given site will depend on local considerations such as roads and topography. Cost will also vary with the hauling distance. Competitiveness with other sources of topsoil will depend on the availability of large quantities of local soil. Surplus soil is occasionally available from construction sites for the cost of loading and trucking. Another consideration is that beneficiaries at both ends of a project may in the future share the cost of obtaining reclaimed topsoil.

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